Dynamic Optimization: Reducing Central Utility Plant Consumption by Over 50 Percent

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EnergyWorks Infrastructure Management

ABSTRACT

This article describes the best practices employed in the systematic upgrade, operation and maintenance of a central utility plant (CUP) and associated energy infrastructure. The CUP provides electrical, heating and cooling services to a 1.4 million square foot super-regional shopping mall in Central Pennsylvania. Since EnergyWorks' acquisition in late 2003, numerous improvements have been made that include:

1. Selective equipment upgrades
2. Automation of best practices in operation and maintenance
3. Designing and installing an energy management system for real-time dynamic optimization.

These improvements not only reduced the plant energy consumption by over 50%; they also reduced the carbon footprint by over 11 million pounds per year. With advanced energy management systems in place, the shopping mall is assured of a healthy, efficient and sustainable energy service.

BACKGROUND

EnergyWorks owns and operates the CUP and energy distribution infrastructure that provides electrical, heating and cooling services to the 1.4 million sq. ft. Park City Center shopping complex in Lancaster, Pennsylvania. The CUP has been in continuous service since the complex began commercial operations in 1970. The shopping complex is owned by General Growth Properties (GGP).

Since acquiring the Park City energy infrastructure and assuming responsibility for operations and asset management in late 2003, EnergyWorks has modernized the CUP by replacing or upgrading major equipment and implementing state-of-the-art management systems, see Figure 1. These measures have reduced the annual CUP electrical and heating commodity consumption by over 50% and have improved the consistency of comfort and indoor air quality within the mall complex.

Figure 1. Park City Central Utility Plant

IMPLEMENTATION

During its first year of ownership, EnergyWorks installed an IT infrastructure in both the CUP and mall complex in preparation for future monitoring and control communications. Additionally, EnergyWorks performed critical system and equipment reconditioning, audited operations and maintenance practices to determine the 5-year baseline (2000–2004) and then identified and prioritized energy conservation and sustainability opportunities.

During the second year of operations, an industrial SCADA (supervisory, control and data acquisition) system was installed with the initial objective of integrating collection, analysis and display of process and operations data. Changes to CUP systems and equipment included reconfiguration of piping for modified equipment sequencing, replace-

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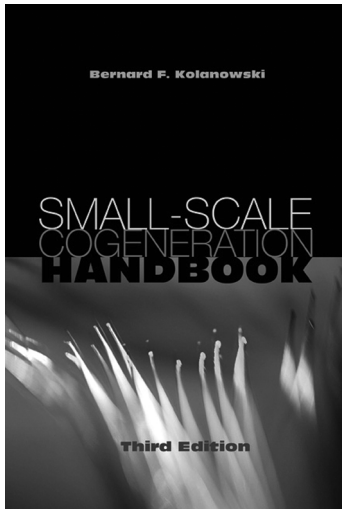

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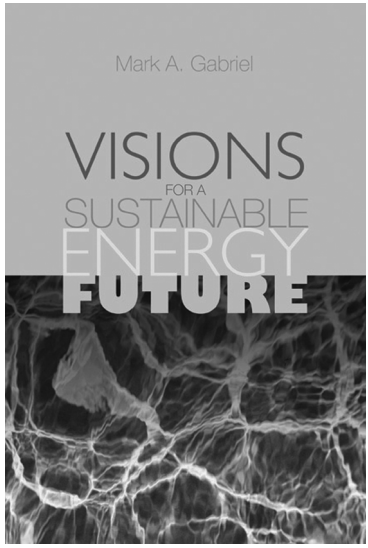

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ment of two aging constant speed centrifugal chillers with a single variable speed chiller and conversion of the chilled water primary distribution loop from constant flow to variable flow. Liquid fuel for the plant's dual-fuel boilers was changed to a blend of heating oil and soy-based bio-fuel.

These and other changes significantly reduced the energy use of the central heating and cooling systems and provided real-time visibility of process conditions, space occupancy, indoor comfort and outdoor meteorological conditions. Multi-variant regression analysis was used to calculate and display whole campus performance on the basis of energy input vs. delivered heating and cooling service. Performance monitoring enabled operators to receive immediate feedback on the overall effect of systems adjustments. This feedback allowed the operators to react more effectively to changes affecting heating and cooling loads and accelerated the identification of best practices for high quality service and efficient operations. As experience showed, the potential to further reduce energy consumption through effective and timely response to dynamic conditions, real-time response or *dynamic optimization* became the operational objective.

Dynamic optimization could only be achieved through automation of previously manual operations. During the third year of operations, plant features were designed and installed to automate startup, shutdown, sequencing and adjustment of systems and equipment. This provided not only more consistent operations to maintain greater efficiencies; it also freed up plant personnel for additional maintenance and in-house completion of capital projects.

Once the CUP automation was well underway, EnergyWorks began installing remote reading electric meters and upgrading individual tenant and common area air-handling units (AHUs). Utilizing the previously installed fiber optic communications backbone, remote monitoring and control of energy distribution and individual AHU operations became better integrated with CUP operations.

By the end of the third year, equipment upgrades and improvements in operations had reduced CUP energy consumption by more than 50% compared to the 5 year baseline, see Figures 2 and 3. Improvements in energy distribution and end-use management have provided another 20% reduction compared to the baseline. In addition to the cost savings, the reduced energy consumption eliminates over 11 million pounds per year of greenhouse gas emissions (see Figure 4) and has allowed a 58,000 sq-ft addition to mall tenant spaces without the need for additional CUP capacity.

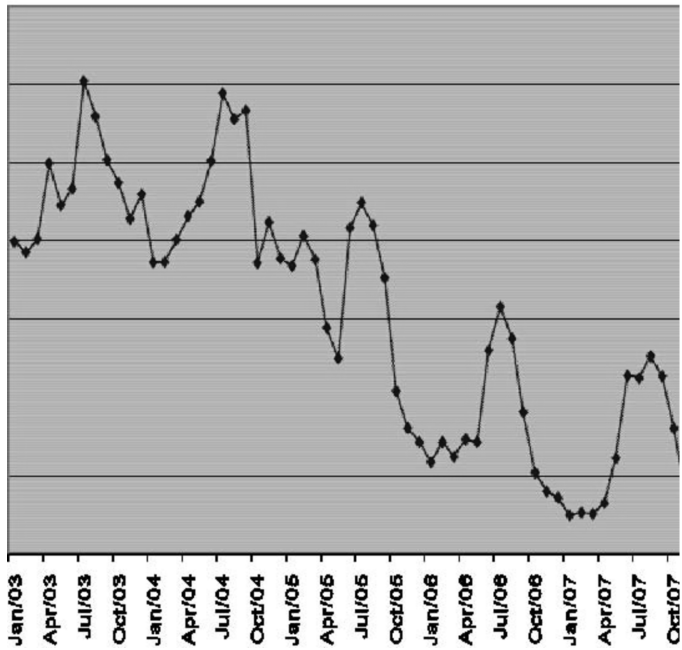

Figure 2. CUP Electrical Usage (2003-2008)

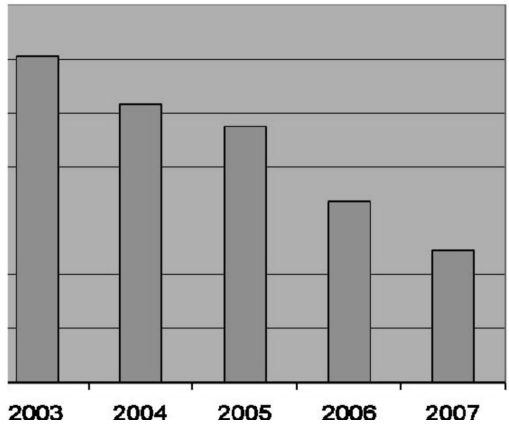

Figure 3. CUP Energy Usage (2003-2008)

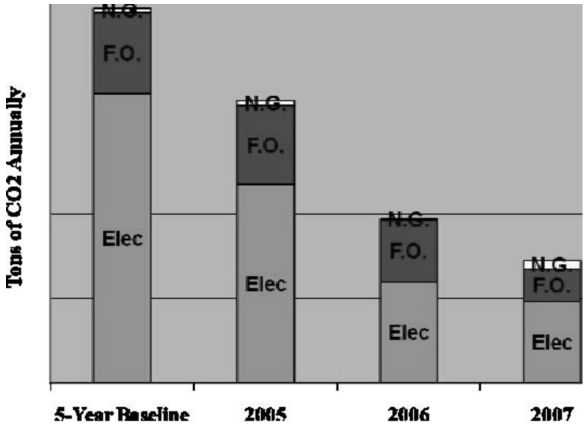

Figure 4. CO_2 Emissions

ENABLING INFRASTRUCTURE

EnergyWorks employs an open communications protocol and technology neutral policy that has allowed for ease of systems integration. The SCADA system was installed and programmed to work in conjunction with the mall BACnet BAS. The CUP utilizes high accuracy sensors to gather real-time data on equipment, meteorological conditions, process parameters, mall occupancy people counters, indoor-air quality (IAQ) sensors and individual tenant spaces to continually optimize plant operations.

Additional utilization of the IT infrastructure enabled automated electric meter readings and transition to predictive maintenance, providing more cost effective use of labor and materials. The IT backbone also enabled additional service offerings such as WiFi service for mall patrons, traffic data and common area lighting control.

ELECTRICAL DEREGULATION

EnergyWorks is currently installing a 6 MW power generation system for greater flexibility and agility in managing future energy costs as the local electricity market completes its ten-year transition to full deregulation. The system will provide capacity to support smart-grid strategies for energy purchases, load curtailment and ancillary services. It will also provide backup power to the mall complex.

The existing communications infrastructure will enable EnergyWorks to execute real-time make-versus-buy decisions in the electricity wholesale spot market or to participate in PJM demand response programs in cooperation with mall tenants. Backup power will avoid business interruptions and may reduce tenant insurance rates. The ability to maintain power during an electric grid outage will provide a valuable public service to the Central Pennsylvania region.

CONCLUSIONS

It is no longer sufficient in terms of business costs or environmental stewardship to limit system optimization for static conditions upon initial commissioning or even seasonally thereafter. Experience at the Park City Center shopping complex has shown that it takes real-time response to dynamic conditions or *dynamic optimization* to realize the full potential in energy efficiency and environmental stewardship. Dynamic optimization is best employed when management of technology and operations is placed in the hands of an experienced and focused team with incentives for long-term investment. The resulting economic, environmental and community benefits provide real progress toward sustainability.

ABOUT THE AUTHOR

Kevin Bauer joined EnergyWorks in 2006 and serves as the Operations and Engineering Manager. During that time he has managed operations to streamline maintenance practices, design and automate plant and building operations, and increase system-wide efficiencies. Prior to joining EnergyWorks, Kevin served as a US Navy nuclear submarine officer for 8 years. He received a BS in Computer Science from the US Naval Academy, been certified by the DOE in Nuclear Engineering and earned a MEM in Engineering Management from Old Dominion University. Kevin may be contacted at kbauer@energyworks.com.